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APPLICATION

FOR

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TITLE: HIGHLY REFLECTIVE OPTICAL COMPONENTS

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HIGHLY REFLECTIVE OPTICAL COMPONENTS

This invention relates generally to precision optical components which are highly reflective.

Highly reflective mirrors are needed in a variety of microelectronic applications. For example, liquid crystal over silicon (LCoS) light modulators are utilized in microdisplays and projectors. In many cases, the reflectivity of these mirrors defines the performance of the overall display or projector. The poorer the reflectivity of the mirrors, the more light must be utilized to illuminate a display screen or a display as the case should be. If more light is not available, which is commonly the case, then the resulting image is simply washed out.

A micromirror functions to reflect incident light. Its ability to reflect light with an appropriate light spectra defines the quality of the resulting image. Moreover, the micromirror's ability to reflect light also affects a number of other optical components including the available spectra, the available power, and the temperature of silicon memory, as well as liquid crystal and optical components. As a result, the stability of many devices may be determined by the quality of the mirrors. Mirrors with relatively lower light reflectivity may require higher

power lamps increasing the temperature of all display elements.

As a result, display vendors are trying to develop micromirrors with the highest possible light reflectivity. Nonetheless, the best reflectivity reported to date is in the lower ninety percent reflectivity, using aluminum or aluminum plus 0.5% copper mirrors.

Thus there is a need for better performing reflectors for use in higher performance optical components.

Brief Description of the Drawings

Figure 1 is an enlarged, cross-sectional view of one embodiment of the present invention;

Figure 2 is an enlarged, cross-sectional view of another embodiment of the present invention;

Figure 3 is idealized representation of the percent improvement in reflectivity of a silver reflector compared to an aluminum plus 0.5% copper reflector over the visible wavelength spectra; and

Figure 4 is a graph of percent reflectivity versus wavelength for a plurality of different silver containing reflective surfaces in accordance with embodiments of the present invention.

Detailed Description

Referring to Figure 1, a silicon wafer or other substrate 16 may be coated with a layer 14 of silver, a

layer 12 of silicon dioxide and a layer 10 of silicon nitride. The layer 14 provides high reflectivity. The layers 10 and 12 may provide isolation from liquid crystal materials in those applications where it is desired to separate the reflective material from a liquid crystal material.

The silver layer 14 may be deposited by direct current or dc-sputtering on the surface of a polished silicon wafer at a substrate temperature not higher than 50°C. In the illustrated embodiment, pure silver is utilized for the layer 14. While generally the use of silver is avoided in semiconductor processes, the deleterious effect of silver on silicon may be substantially lessened by depositing the silver at low temperature.

In one embodiment, each of the layers 10 and 12 may have a thickness of about 700 to about 750 Angstroms. Advantageously, the layers 10 and 12 are deposited using chemical vapor deposition techniques at temperatures not higher than 250°C. The use of relatively low temperature deposition techniques (normal deposition techniques may involve temperatures of 400°C) may be effective to form layers with relatively small grain sizes.

In Figure 2, the layers 10 and 12 of Figure 1 are replaced by a thicker layer 16 of silicon dioxide. The layer 12 in Figure 2 can be formed of a thickness of approximately 3000 Angstroms using chemical vapor

deposition techniques and temperatures not higher than 250°C in one embodiment.

The inventor of the present invention has determined that the use of silver as a reflector is highly advantageous compared to the use of aluminum and particularly to the use of aluminum plus 0.5% copper. The use of aluminum plus copper has been credited with achieving the highest commercially available reflectivities on the order of ninety percent. As shown in Figure 3, a significant reflectivity improvement, on a percentage basis, can be achieved using silver compared to aluminum plus copper.

Referring next to Figure 4, as would be expected, coating the silver films with silicon dioxide or silicon dioxide plus silicon nitride, decreases the reflectivity of the resulting composite. However, this may be necessary in some applications involving liquid crystal materials. What is more interesting though is the blue shift that occurs when using silver covered by 750 Angstroms of silicon dioxide and 750 Angstroms of silicon nitride.

The peculiar drop in the reflectivity of blue light is particularly noticeable compared to the results for silver covered by 3000 Angstroms of silicon dioxide. Clearly, the inclusion of silicon nitride in the overcoating has a dramatic (negative) effect on the reflection of blue light. In addition, the use of two relatively thin insulator

layers with relatively small grain sizes may contribute to the blue shift.

Reducing the reflection of blue light, in particular, from a reflective surface may be advantageous in many applications. For example, many lamps utilized in connection with projection displays over produce blue light relative to other visible light wavelengths. In other words, the light produced has a spectra that includes more blue light than normal ambient light. This imbalance may be corrected by using a reflector that produces a blue shift. The result of using a reflector including a coating of silicon nitride may be to reduce the amount of reflected blue light and to thereby automatically rebalance the spectra of the lamp or light source.

While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is: